THE ARCTIC CHAR *(Salvelinus alpinus)* EXPERIMENTAL FISHERY IN KANGIQSUALUJJUAQ, QUEBEC, 1987-1988

By:

Tom Boivin
Stas Olpinski
Peter May

A Scientific Report Submitted to:

Ministère de l'Agriculture, Pêcheries et Alimentation
and
Ministère du Loisir de la Chasse et de la Pêche

Kuujjuaq Research Centre
Makivik Corporation
Kuujjuaq, July 1988

THE ARCTIC CHAR *(Salvelinus alpinus)* EXPERIMENTAL FISHERY IN KANGIQSUALUJJUAQ, QUEBEC, 1987-1988

By:

Tom Boivin
Stas Olpinski
Peter May

A Scientific Report Submitted to:

Ministère de l'Agriculture, Pêcheries et Alimentation
and
Ministère du Loisir de la Chasse et de la Pêche

Kuujjuaq Research Centre
Makivik Corporation
Kuujjuaq, July 1988

Table of Contents

Acknowledgements

We would like to thank all Kangiqsualujjuamiut who participated in the subsistence fishery study by recording their harvests or answering questionnaires. The assistance of David Annanack, the commercial fishermen, Simeonie Baron, Tommy George Etok, Thomas Edward Annanack, and Tommy Stanley Annanack both in the field and in Kangiqsualujjuaq was a key factor in our overall success. Louis Roy (M.L.C.P.) and Fritz Axelson (M.A.P.A.Q) provided valuable advice and assistance during various stages of this project. Allen Gordon assisted the research team in the reading of otoliths. Morrie Portnoff provided the graphics for this text, and also assisted in word processing. Dave Gillis (SEAKU fisheries) was very helpful with our numerous questions throughout the planning stages of the project and during analysis of data. Finally, we would like to acknowledge the hospitality and assistance of Bobby Baron, Tommy L. Annanack, Marguerite Kopiec and Christina Baron during our time spent in Kangiqsualujjuaq.

Introduction

Background

At present, the two main commercial fisheries for arctic char (*Salvelinus alpinus*) in Canada are undertaken in northern Labrador and the Cambridge Bay area in the Northwest Territories. Both these fisheries are summer operations which capture char in the sea or during their upstream migration (Dempson and Kristofferson 1987). Conversely, the experimental char fishery undertaken from November, 1987 to April, 1988 in Kangiqsualujjuaq, Quebec, is a winter fishery with fish being captured with gillnets set beneath freshwater ice. Such a fishery provides a unique opportunity to not only examine the feasibility of such an endeavor, but also to collect much-needed biological data on the stocks at the same time.

Our current knowledge of arctic char biology in northern Quebec is rather limited; most data has been collected from the Ungava Bay region, particularly in the Kangiqsualujjuaq area (Grainger 1953; LeJeune 1967; Gillis et al. 1982; Barton et al. 1985; Boivin 1987 and Gillis 1988). The collection of biological data on the char stocks of this area is essential for providing management information, as well as to assist in the development of sustainable yields for the commercial fishery.

Past commercial arctic char fisheries in northern Quebec were failures, mainly because allocated quotas were too high and there was a lack of knowledge regarding the effects of exploitation on this species (Gillis et al. 1982). A detailed description of the 1960's char fishery in the Kangiqsualujjuaq area is provided by Boivin (1987) and Gillis (1988). With this past experience in mind, fisheries managers must be cautious when determining exploitation rates for each fishing location in the region. Of foremost concern is the subsistence harvests (see NHR 1982; Boivin 1987), which must take precedence over the commercial fisheries.

Fish species captured

According to the NHR (1982) study, the main fish species harvested by Inuit of Kangiqsualujjuaq, in decreasing order of importance (total edible weight) are: arctic char, lake trout (*Salvelinus namaycush*), brook trout (*S. fontinalis*), Atlantic salmon (*Salmo salar*), lake whitefish (*Coregonus clupeaformis*), sculpins (*Myoxocephalus* spp.) and cod (*Gadus morhua* and *G. ogac*). The latter two species are captured primarily during the short summer fishery. White suckers (*Catostomus catostomus*) are also harvested on occasion in the George River. Table 1 lists the salmonid fish species harvested by gillnet from river and lake systems in the Kangiqsualujjuaq area.

Sites fished commercially and for subsistence use

Of the 12 systems listed in the proponent's fishing permit (Figure 1), only 5 were fished commercially in 1987-88 (Koroc, Qarliik, Tasikallak, Akilasaaluk and Ijjurittuq). Lake Sanirarsiq was also fished during an experimental sampling program. In general, the fishing sites closest to the community (Koroc, George R., Tasikallak) are the most important in terms of subsistence use; more distant systems (Akilasaaluk and Ijjurittuq) have only been fished extensively in the past 5-6 years (Boivin 1987).

Commercial fishing for arctic char (for sale to beneficiaries both in Kangiqsualujjuaq and other communities) has taken place in this area for at least 10 years. During these intensive fishing periods, most char were captured from Koroc and Tasikallak; 71 % of the total commercial catch during the winter of 1985-86 originated from these 2 sites (Boivin 1987).

Fishing activities in the Kangiqsualujjuaq area in winter are restricted by two main factors: trail conditions and weather. In November and early December, the river and lake ice are stable enough to permit travel to nearby fishing sites. Koroc R. receives most of the early winter fishing effort and is fished very intensively by many local fishermen. By mid-December, weather and ice conditions permit travel on the sea ice, and more distant locations may then be fished (Tasikallaq, Ijjurituq, etc.). Once distant systems are accessible, subsistence fishing effort drops dramatically at Koroc R. and becomes more dispersed. In spring, as trail conditions deteriorate, Koroc R. is once again the only accessible fishing site, and fishing effort increases. Fishing activities at this time also take place in the Tunulliq and Amarurtaliup areas west of Kangiqsualujjuaq.

Since the commercial quotas allocated to the proponent generally increase with distance of system from the community, it is probable that no system more distant than Tasikallak could be fished before mid-December, nor any later than the end of April. With the late start of the fishery in 1987 (November 27), plus the lack of appropriate freezing facilities for the catch, the 1987-88 commercial fishing season was shorter than what is to be expected in the future.

Methods

Fieldwork was conducted between 27 November, 1987 and 15 April, 1988 in Kangiqsualujjuaq, Quebec. The research staff travelled by snowmobile with the proponent to all sites commercially-fished and sampled the entire catch at each site. The methods outlined here are discussed further in Olpinski et al. (1988) and are similar to those used by Boivin (1987).

Fishing effort

At the fishing sites, a record was kept of number of fishermen, number of nets set, length and mesh size of net, time nets were set beneath the ice and the time of each net check. In this study, catch per unit of effort (C.P.U.E.) is expressed both in terms of gillnet-days (mean total length of all nets set and the total catch at a given location each day), and also in terms of total weight (kg) of fish captured per 'net set'. Berkes (1979) used the term 'net set' (defined as the period between setting and checking a gillnet) as the unit of fishing effort in a study of James Bay Cree domestic fisheries; since mean catch of fish (kg) did not vary in any systematic way with the total time a net was set, he found this measure of C.P.U.E. to be most accurate for a subsistence fishery. Boivin (1987) also used this unit to describe winter fishing effort in Kangiqsualujjuaq in 1985-86. Catches per net set are therefore presented in this report, so that the reader may compare past C.P.U.E. with that experienced during the 1987-88 commercial fishery.

Biological sampling

i) Commercial fishery

All fish captured in the commercial fishery (N=2116) were sampled by the research team before being processed. Arctic char were sexed by visual characteristics including shape and size of head and degree of kype formation. Maturity (non-spawner or spent) was also determined by visual characteristics; 'silver' char are designated as not having spawned the previous fall, whereas 'red' char are described as contributing to the fall spawning run. Both sex and maturity were confirmed by examination of the gonads of a sub-sample of the total catch.

All fish were measured for fork length ($\pm$0.5 cm) and whole weight ($\pm$50 g). A minimum of 150 char (or the entire quota if less than 150 fish) were systematically-sampled for aging. Saggital otoliths were examined with reflected light and a stereoscopic microscope according to the method of Nordeng (1961). Each of the 3 readers verified the aging technique with the other researchers to ensure uniformity of results.

ii) Scientific fishery at Sanirarsiq

With the objective of sampling a cross-section of a 'natural' fish population to compare the size distribution of the catch with that of exploited systems, the research team used 4 geometric gang-mesh nets (stretched measures (cm): 15.2, 11.4, 7.6, 6.4, 5.1, 3.8 and 2.5) to sample the char stock at Sanirarsiq. Fieldwork was undertaken between 10 March and 14 April, 1988, during which time 3 separate trips were made to the site.

Sampling sites were randomly chosen to minimize any bias in location of net placement (Figure 2 shows sampling sites at Sanirarsiq). Besides the aforementioned biological data collected at commercial fishing sites, pectoral fin rays were collected to test their validity as an aging structure. At present, these analyses have not been attempted; it is expected that a sub-sample of the finrays will be sectioned and examined during the fall of 1988, and that preliminary results will be presented before the start of the 1989 fishing season.

A record of the catch selectivity of the gang-mesh nets was also recorded. Catches were 'non-selective' if the fish were captured by the teeth, or were tangled in the mesh; a 'selective' catch was one in which the fish were captured by the gills or body. A small number (5) of char were also sampled by jigging during the experimental fishery.

Subsistence Harvest Study

To obtain an estimate of the total subsistence catch by the community, harvest booklets were distributed on 30 November, 1987, to all households in the community (N=78); a total of 93 potential fishermen were surveyed. Fishermen were asked to record: date, location fished, number of nets used, and number of char (or other species) captured by net, jigging or kakivak (fishing spear). Fishermen were visited twice over the course of the winter (10 February and 19 April, 1988) to check whether harvest records were up-to-date. If not, the hunter was asked to answer a questionnaire concerning catch and harvest effort. Estimates of the total fish harvest of the community were calculated from both booklet and questionnaire data; reported catches in booklets were used to estimate the total harvest according to the method outlined by Dumas et al. (1984).

Statistical analyses

Statistical analyses were performed primarily with MacIntosh Apple computers and the program 'Statview' (Brainpower, Inc. 1985). For all statistical tests, assumptions of normality and homoscedasticity were verified. Normality of data was tested using a graphic test of frequency distributions (Sokal and Rohlf 1981); homogeneity of variance was verified by checking for correlation between plots of means and standard deviations of samples.

Statistical analyses for comparisons of mean lengths, weights, and ages between locations were performed using analysis of variance (ANOVA) according to the procedure outlined by Statview (Brainpower, Inc. 1985). Instantaneous rate of mortality (Z) was calculated from catch curves (natural logarithm of frequency of ages in the catch plotted vs age) according to the method described by Ricker (1975). Linear regressions were calculated by the method of least squares. The maximum probability of a Type-1 error was set at 0.05.

Results and Discussion

Total catch and species composition of the winter harvest

i) Commercial fishery

During the winter fishery, at total of 2116 Arctic char were harvested by the proponent. One brook trout was captured at Akilasaaluk; the remainder of the catch was char. Numerous lake trout (26) were captured during the experimental fishery at Sanirarsiq, however this species was not obtained at any location in the commercial fishery.

ii) Subsistence Fishery

The result of the subsistence harvest study (Table 2) show that a total of 4101 arctic char were harvested by the community during the winter of 1987-88; the combined subsistence and commercial catch was 6217 char. This result is comparable, although higher, to Boivin's (1987) estimate of subsistence char harvest in the winter of 1985-86 (3740 char). 62.5% of the total 1987-88 winter harvest came from Koroc River; a total of 2564 char were reported captured here. Lake Tasikallak harvests were second with 673 char (16.3% of total) while George River provided 643 (15.2%) of the total community catch.

The total harvest from Koroc River was much higher than reported during 1985-86; in that year winter catches of char were almost equal at both Koroc and Tasikallak (2100 and 2075 char respectively), and these two locations accounted for 71% of the total community catch (Boivin 1987). The total subsistence catch from George River was also higher in 1987 than in 1986, when 247 char were harvested by the community. Of the 5 other fish species reported captured in the subsistence fishery, (Table 3) 83.2% of the total (381 fish) were captured from George River. 26% (n=257) of the total George River catch was whitefish. A total of 9 Atlantic salmon were reported captured at Koroc River, and 3 at George River.

The percentage contribution of each species to the total subsistence catch is shown in Table 4 . Of the 4482 fish harvested for subsistence purposes, 91.5% was arctic char. This figure is slightly below the 95.6% reported by Boivin (l987); the increased whitefish catch (5.7% of total) at George River is mainly responsible for this difference.

Fishing effort:

CPUE (Tables 5 and 6) was highest at Lake Tasikallaq, where an average of 63.0 kg were captured per net-day. At this location, an average of 326 m of gill net was used for the 2 fishing days; this was the longest length of gill net set at any one location on a given day. A mean of 36.8 kg were captured per net-set at Tasikallaq; Boivin (l987) reported an average catch of 19.0 kg per net-set (N=41) in the subsistence fishery in l985-86. CPUE at Ijjurittuq was second highest in terms of catches per net-day (27.2 kg), but second-lowest in numbers of char captured per net-day. Boivin (l987) reported a subsistence catch of 19.7 kg per net-set (N=22); in the 1987-88 fishery, CPUE was 23.8 per net-set (N=121). CPUE was lowest at Koroc River in terms of both numbers of char captured and kg per net-day and net-set; fishermen were harvesting only l6.2 kg per net-day (11.7 kg per net-set).

Length, Weight and Age of the Catch:

The average fork length of the commercial catch was 59.23 cm (N=2116) and average whole weight was 2477.89 kg (N=2114) (Table 7). The smallest char were sampled at Lake Qarliik (54.34 cm; 1766.53 g), and the largest at Ijjurittuq (63.07 cm, 3056.22 g); there was a general trend of increasing mean fork length and whole weight with distance from the community; this difference was highly significant (ANOVA; $p<0.0001$). Since differences in mesh size employed will affect the size range of the catch, data were also analyzed according to meshes used at each site. At all but one fishing location, a 12 cm stretched mesh was used; for Ijjurittuq it was 14.0 cm. For all sites where the 12 cm mesh was employed, significant differences in mean weights and lengths were evident (ANOVA; $p<0.0001$). However, mean lengths were almost identical at Koroc, Qarliik, and Tasikallak ($p>0.25$); significant differences ($p<0.0001$) were found in weights between all locations except Tasikallak and Qarliik (t-test; $p>0.25$).

The summary statistics for arctic char and lake trout captured with the experimental gang-mesh nets are listed in Table 8. For char, the mean length was 61.03 cm (range:12.5-77.0 cm; N=278), mean whole weight was 2684.93 g (range:8-5450 g) and mean age was 11.04 years (range:4-18 years). For lake trout, the mean length was 39.89 cm (range 12.5-95.0 cm; N=26), mean weight was 1520.63 g (range:15-8400 g) and mean age was 13.77 years (range 5-48 years).

The experimental gang-mesh nets used at Sanirarsiq proved to be highly non-selective (Tables 9 and 10). 65% of all char, and 35% of all lake trout were captured non-selectively (caught by teeth or were tangled in the mesh). The inefficiency of the experimental nets for harvesting arctic char was most apparent for the 3.8 cm mesh, where 93% of all fish were captured non-selectively. There was a general trend of increasing mean size of fish captured with mesh size as expected; however, the length-range of fish captured with each mesh was very wide. Therefore it is difficult to determine whether a true cross-section of this 'natural' stock was sampled during the experimental fishery. Nevertheless, interesting results were obtained, and the data is presented in the figures as a comparison to the catches obtained from the commercial fishery.

The length-frequency distribution of the commercial catch is shown in Figure 3. The modal size of fish captured at all locations where the 12 cm mesh was employed (locations A-D) was 55-60 cm; however, for char captured at Ijjurittuq (14 cm mesh) and Sanirarsiq (gang-mesh net), the mode was at 65 cm. The weight-frequency distribution of the commercial catch (Figure 4) showed a similer pattern. Weights of char captured in 12 cm mesh (locations A-D) were generally in the 1.5-2 kg mode; the modal weight for Ijjurittuq char was at 3 kg, whereas the modal weight of Sanirarsiq char was undefined, but was between 2-4 kg.

The general trend of increasing mean morphometric variables with distance from the community was also apparent for age data (Table 11). The mean age of the commercial catch was 10.08 years. The oldest char (l9) was harvested at Ijjurituq while the youngest (5) from Akilasaaluk and Tasikallak; however, 3 char aged 4 years were harvested at Sanirarsiq. The widest range of ages captured at any commercial site was at Tasikallak (12 yrs). The range of ages captured during the experimental fishery was 4-18. At locations where the 12 cm mesh was employed, there was a significant difference in ages between locations (ANOVA; $p<0.0001$).

The same relationship was found when commercial ages from all locations were analyzed ($p<0.0001$). Paired comparisons of mean ages were significantly different between all locations, except between Qarliik and Akilasaaluk (t-test; $p>0.25$). The age-frequency distribution of the commercial catch is shown in Figure 5. All sites fished with the 12 cm mesh (locations A-D), showed strong modes at either age 9 or 10. Most char captured at Koroc, Qarliik and Tasikallaq were in younger age classes, while larger numbers of older fish were sampled at locations farther from the community. The experimental fishery at Sanirarsiq showed a strong mode at age 10, but most of the catch was in older age classes.

The length, weight and age distribution of the entire commercial catch are presented in Figure 6. In the total catch, the modal length was 60 cm, modal weight was 2.5 kg and modal age was 10 years. For each morphometric variable, there was secondary modes in the proximate ranges.

<u>Sex ratio, Coloration and Maturity</u>:

The sex ratio of the commercial catch was dominated by males, with the male-female ratio being 1.58:1 (1285:818) (Table 12). Females represented 38.9% of the total catch; only at Koroc and Akilasaaluk did the ratio approach equality. This difference in sex ratio was particularly apparent at Tasikallak, where 26.1% of the catch was female; at Qarliik and Ijjurittuq, the male female ratio was 2:1 or greater. Boivin (l987) also found a significant difference in the sex ratio of char captured in the subsistence fishery at Tasikallak (male-female ratio 1.76:1; G-test, $p<0.05$).

Silver char also dominated the catch at all locations; only l9.1% of the catch from all locations was red (spent) char. The percentages of red char in the catch ranged from 16.9% (Akilasaaluk) to 25.9% (Tasikallak). The youngest spent char was found at age 6 and the oldest at age 17 (both were males sampled at Ijjurittuq). In the experimental fishery, the youngest spent fish was age 10 (a female), and the oldest age 15 (a male).

During the experimental fishery at Sanirarsiq, the technique for determining sex and maturity from external characteristics was verified. 91.4% accuracy (N= 267) was obtained when sexing char by visual characteristics. Of the 23 fish sexed incorrectly, 11 designated as females were, in fact, males. Thus, when using this method of sex determination, there does not appear to be a difference nor selective bias between sexes. Determinations of maturity from external coloration (red or silver) showed similar results; 94.4% of all determinations of maturity were accurate (N=267). Most (80%; N=15) 'incorrect' determinations of maturity were silver female char which appeared to have spawned the previous fall. Despite this exception, the methods for determining sex and maturity by visual inspection appear to be accurate.

Growth

The slow growth of arctic fish populations has been well documented (Johnson 1976; Power 1978). Such stocks are characterized by populations of large and old fish. The growth curves (length vs age) of char samples (both sexes combined) obtained from the commercial fishing locations and the experimental sampling site show a high variation in growth rates (Figure 7; Tables 13-18) from different areas. Perhaps the most striking feature of the growth data is the overlap of length ranges between different age groups; this is particularly evident at Tasikallak, where growth appears to be slow between ages 9-13. An overlap in length-at-age data is characteristic of char populations in the N.W.T. (Johnson, 1980).

At Sanirarsiq, the population appears to have a very slow growth rate; this lightly-exploited system probably is still mainly comprised of old and large individuals. Ijjurittuq, another relatively lightly-fished system, appears to have a population of large individuals, and the range of lengths-at-age appear to be quite similar to Sanirarsiq. Conversely, a faster growth rate is apparent for the heavily-exploited stocks (Koroc, Tasikallaq and Qarliik); few large or old individuals were harvested from each of these locations. Akilasaaluk char have a growth rate which is comparable to that found for the heavily-exploited systems, yet has received minimal fishing pressure in the past. Since only one year's data has been analyzed, it is difficult to make in-depth analyses of the growth rates; the collection of data in the 1988-89 winter fishery will prove valuable to this assessment.

The length-weight relationship of the catch from each location is presented in Table 19. The data is presented for the total catch ('all'), for silver char, and also for red char; separation of the length-weight relationships was undertaken, since these data may vary according to season, time of life cycle, and between stocks of the same species (Bagenal 1978). Considerable differences are found between condition of spent and non-spawning char during the winter due to a lack of feeding (Dutil 1986; Boivin 1987), and this is reflected in the length-weight relationship. In all cases, the relationship was highly significant ($p<0.0001$).

<u>Mortality</u>

Only that portion of the stock which is completely succeptible to the fishing gear employed (ie. the next age class after the mode) was used in the analysis of mortality data presented here. Furthermore, 2 separate calculations of exploitation rate (u) are presented, since it is believed that those systems which are lightly-exploited year-round (eg. Sanirarsiq) are best characterized as Type-1 fisheries (natural mortality occurs during a time of year other than the fishing season), whereas heavily-exploited systems (eg. Koroc) are probably Type-2 fisheries (natural mortality occurs along with fishing). Ricker (1975) states that mortality statistics for both Type-1 and 2 fisheries may be calculated over seasons and time if neither model fits a particular fishery. Since winter is a season of continuous heavy fishing pressure on some systems, while others receive only sporadic effort, both calculations of u are presented here.

Instantaneous total mortality (Z) (Table 20) for various systems is estimated to be as follows: Koroc (0.86; ages 10-14); Qarliik (0.79; ages 11-14); Tasikallak (0.79; ages 11-15); Akilasaaluk (0.62; ages 10-13); Ijjurittuq (0.50; ages 11-15); Sanirarsiq (0.40; ages 11-15). It is quite apparent that values for Z decrease considerably with distance of fishing location from the community; Z values for the heavily-exploited Koroc are more than 2 times the value at Sanirarsiq.

The actual mortality rate (A) ranged from 0.58 (Koroc) to 0.33 (Sanirarsiq). The high value of A for Koroc, Qarliik and Tasikallak indicate that individuals in these stocks have little chance of attaining a high age. The survival rate (S) is highest for the unexploited Sanirarsiq stock (0.67) and lowest at Koroc (0.42) and other systems proximate to Kangiqsualujjuaq.

Instantaneous rate of fishing mortality (F) was calculated assuming an instantaneous rate of natural mortality (M) of 0.20. This conservative value for M is used by Dempson and Ledrew (1986) for the Labrador char fishery. Values of F ranged from 0.66 (Koroc) to 0.20 (Sanirarsiq). It appears that fishing mortality is considerably higher at Koroc, Qarliik and Tasikallak than what is experienced at the Nain Assessment Unit (average value for A 1983-85=0.39; Dempson and Ledrew 1986). Although only one season's data is analyzed here, it appears that current fishing pressure on these 3 systems is at or past the level for maximum sustainable yield. Conversely, the Ijjurittuq and Sanirarsiq stocks presently have a low level of fishing mortality. However, it should be noted that the effects of this past winter's fishing mortality will not be evidenced until next year's samples are obtained.

Exploitation rate

Rate of exploitation (u_1) for Koroc was 0.48, indicating that approximately 48% of the fish available to the fishery are removed each year (u_2=0.44). Qarliik and Tasikallaq also experience a high exploitation rate (u_1=0.45; u_2=0.41); Akilasaaluk was considerably lower (u_1=0.34; u_2=0.31). Ijjurittuq and Sanirarsiq experience the lowest rates of exploitation (u_1=0.26 and 0.18 respectively; u_2=0.23 and 0.16 respectively). Kristofferson et al. (1982) suggested a rate of exploitation in a developing fishery should be adjusted to a value of 0.32 (u_1) (F=0.40). Using this value, it appears that the Koroc, Qarliik and Tasikallaq fisheries already exceed the guideline, and therefore commercial harvesting at these systems should not be increased. The exploitation rate at Akilasaaluk is presently almost the same as is stipulated in Kristofferson et al.'s (1982) guideline; however, 552 char were harvested from this small system in 1988, and the effects of this intensive fishing effort will not be recorded until the next sampling season. Exploitation rates at Ijjurittuq and Sanirarsiq are low at present; since Sanirarsiq has be exploited very little in the past, it is suggested that the proponent may fish this and other distant locations more intensively in the future. Commercial fisheries at systems proximate to Kangiqsualujjuaq (Koroc, Qarliik and Tasikallaq), should proceed with caution, in order to ensure that the subsistence fishery is not jeapardized. Next winter's data will prove valuable for determining if present harvest levels at all systems are sustainable in the long-term.

Literature Cited

Bagenal, T. 1978. Methods of assessments of fish production in fresh waters. IBP Handbook No. 3, Blackwell Scientific Pubs., Oxford. 365 p.

Barton, D., T. Boivin, B. de Schiffart, M. Lefevre, P. Lemieux and G. Power. 1985. A feasibility study of the potential for increasing the abundance of anadromous arctic char (*Salvelinus alpinus*) in northern Quebec. Makivik Corporation Research Department. Montreal.

Berkes, F. 1979. An investigation of Cree Indian domestic fisheries in northern Quebec. Arctic 32: 46-70.

Boivin, T. 1987. The winter fishery of Kangiqsualujjuaq, Quebec and winter physiology of arctic char. MSc. thesis, U. of Waterloo. 170 p. + app.

Brain Power, Inc. 1985. Statview. The graphic statistics utility for the Macintosh. Calabasas, CA. 113 p.

Dempson, J.B. and A.H. Kristofferson. 1987. Spatial and temporal aspects of the ocean migration of anadromous arctic char. American Fisheries Symposium 1: 340-357.

Dempson, J.B. and L.J. Ledrew. 1986. Sequental population analysis of the Nain assessment unit arctic char population. CAFSCA Research Document 86/24. Fisheries Research Branch. Department of Fisheries and Oceans. 14 p.

Dumas, R., Gordon, A.H., Gordon, A.S. and M. Koneak. 1984. The Koksoak River fishery: goals, methods and background information. Kuujjuaq. 16 p.

Dutil, J.D. 1986. Energetic constraints and spawning interval in the anadromous arctic char (*Salvelinus alpinus*). Copeia 4: 945-955.

Gillis, D. 1988. Arctic char fisheries management: An evaluation of current methods and the information pertinent to the Nunavik resources. Makivik Corporation. Montreal. Report for the Ministère du Loisir, de la Chasse et de Pêche. 61 p.

Gillis, D., M. Allard and W.B. Kemp. 1982. Life history and present status of anadromous arctic char (*Salvelinus alpinus*) in northern Quebec with case studies on the George, Payne and Kovik Rivers. Kativik Regional Government Inuit Hunting, Fishing and Trapping Support Program. 107 p.

Grainger, E.H. 1953. On the age, growth, reproductive potential and feeding habits of the arctic char (*Salvelinus alpinus*) of Frobisher Bay, Baffin Island. J. Fish. Res. Bd. Can. 32: 1943-1969.

James Bay and Northern Quebec Native Harvest Research Committee. 1982. Montreal. Research to establish present levels of native harvesting. Harvests by the Inuit of northern Quebec. Phase II (Yr. 1979 and 1980). Montreal.

Johnson, L. 1976. Ecology of arctic populations of lake trout, *Salvelinus namaycush*, lake whitefish, *Coregonus clupeaformis*, arctic char, *Salvelinus alpinus*, and associated species in unexploited lakes of the Canadian Northwest Territories. J. Fish. Res. Bd. Can. 33: 2459-2488.

Johnson, L. 1980. The arctic char (*Salvelinus alpinus*). p. 15-98. *In*: Charrs: salmonid fishes of the genus *Salvelinus*. E.K. Balon (ed.). Dr. W. Junk Publishers, The Hague.

Kristofferson, A.H., Leroux, D.R. and J.R. Orr. 1982. A biological assessment of arctic char, *Salvelinus alpinus* (L.), stocks in the Gjoa Haven-Pelly Bay area of the Northwest Territories 1979-1980. Can. Man. Rep. Fish. Aquat. Sci. No. 1591. 51 p.

LeJeune, R. 1967. L'omble chevalier anadrome du Kagnersoualoudjouark (sic). Province de Quebec Ministere du Tourisme, de la Chasse et de la Peche. Service de la Faune. 45 p.

Nordeng, H. 1961. On the biology of char (*Salvelinus alpinus* L.) Salangen, north Norway. 1. Age and spawning frequency determined from scales and otoliths. NYTT Magasin for Zoologi. 10: 67-123. Oslo University Press.

Olpinski, S., Boivin, T. and P. May. 1988. Monitoring of the 1987-88 experimental commercial and exploratory arctic char (*Salvelinus alpinus*) fisheries in Kangiqsualujjuaq, Quebec. Field report submitted to M.A.P.A.Q. and M.L.C.P. 27 p.

Power, G. 1978. Fish population structure in arctic lakes. J. Fish. Res. Bd. Can. 35: 53-59.

Ricker, W.E. 1975. Computation and Interpretation of biological statistics of fish populations. Bulletin #191 of the Fisheries Research Board of Canada. Department of the Environment. Fisheries and Marine Service. 382 p.

Sokal, R.R. and F.J. Rohl. 1981. Biometry. Second edition. W.H. Freeman and Co., New York. 859 p.

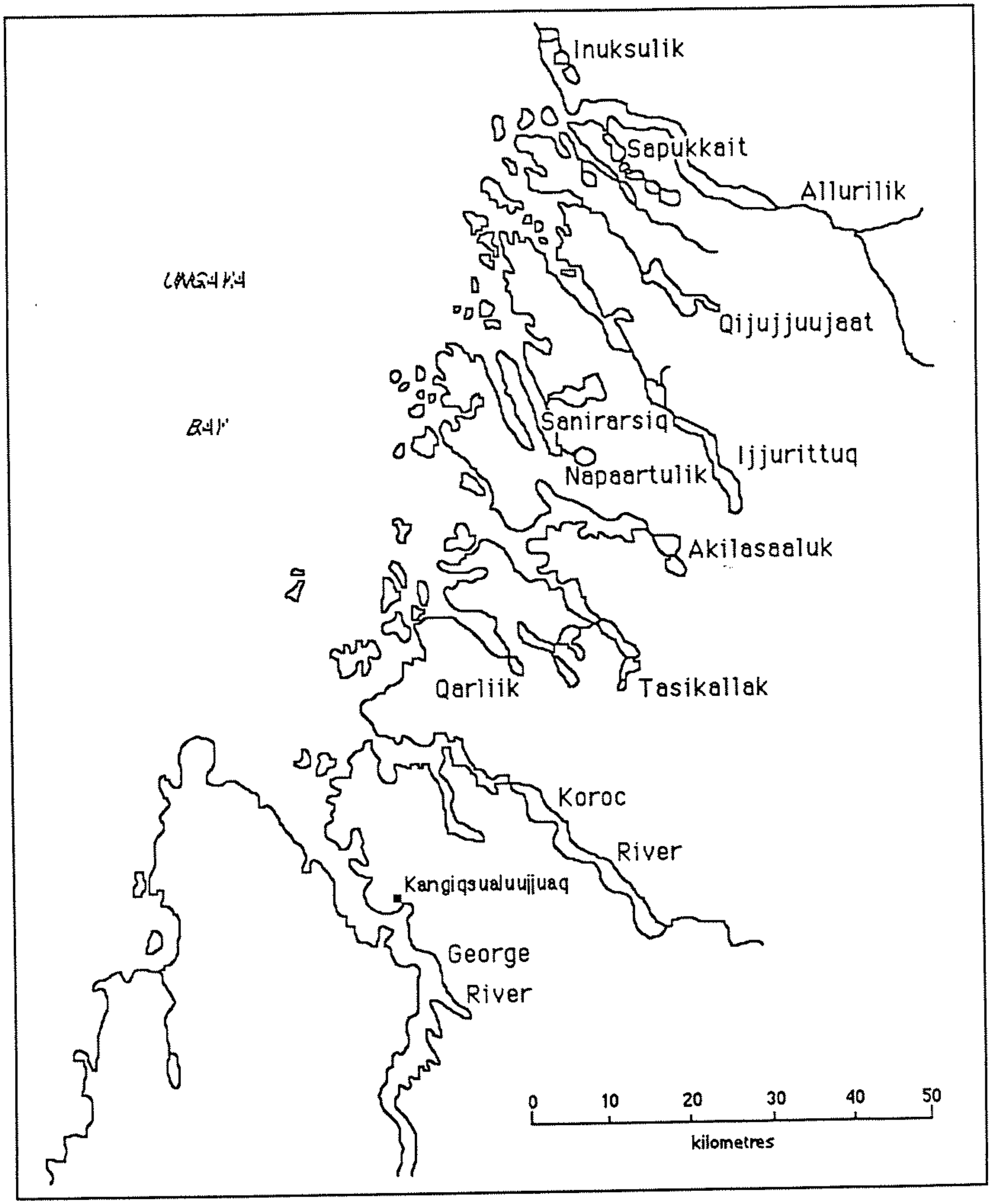

Figure 1: Arctic char systems listed for exploitation during the 1987-88 winter fishery.

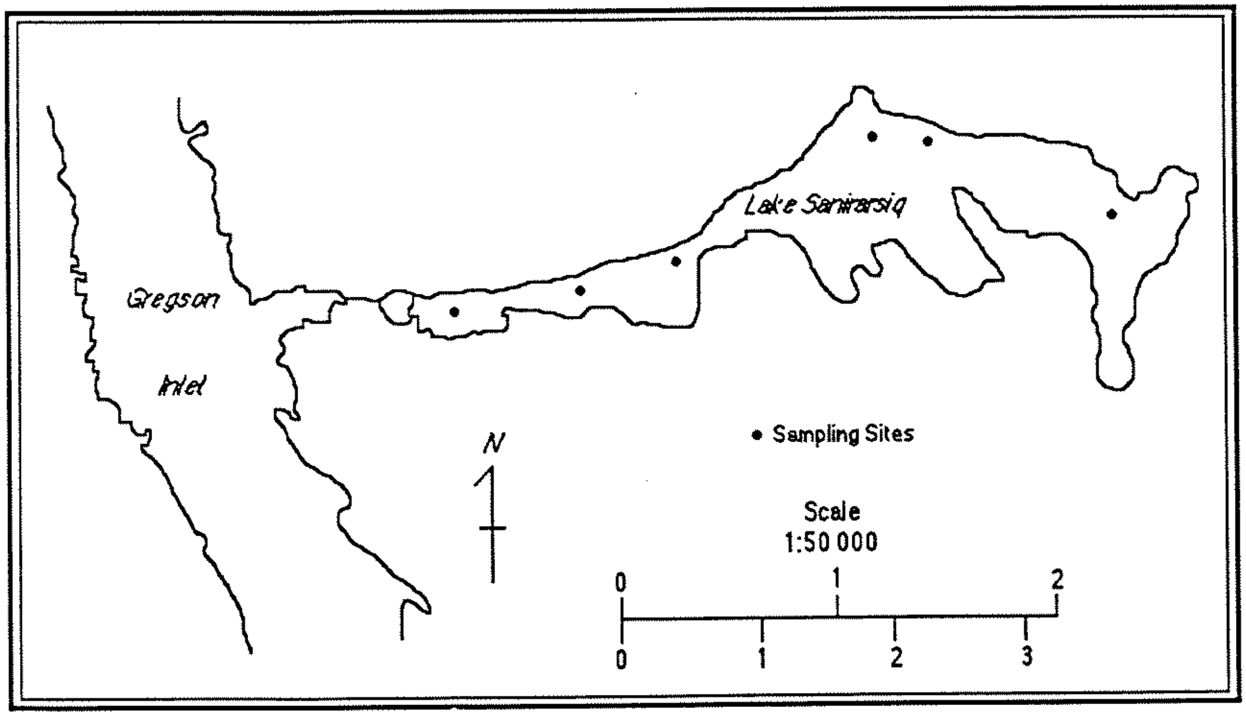

Figure 2: Sampling sites for exploratory fishery at Sanirarsiq

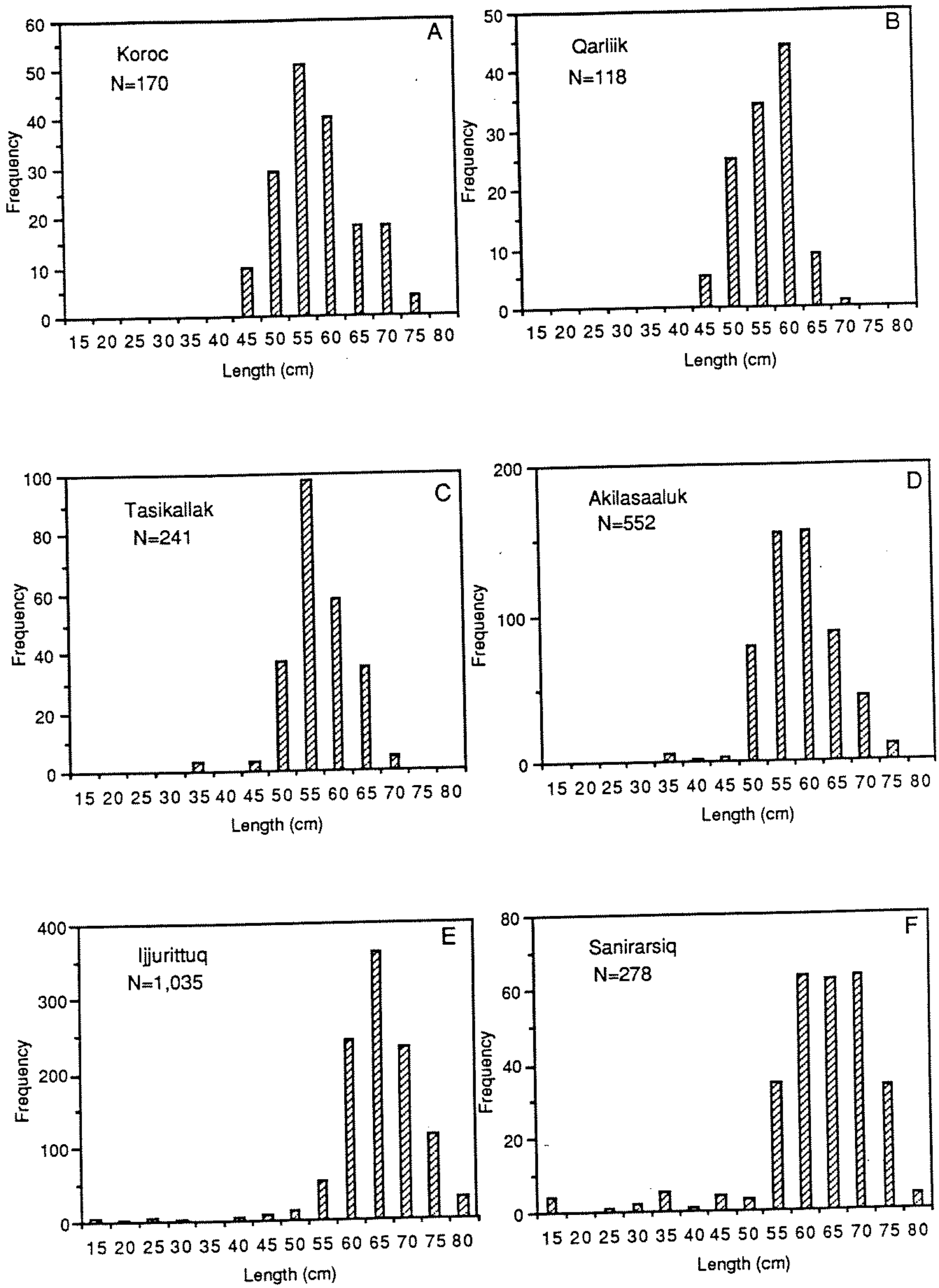

Figure 3: Length-frequency distribution of the arctic char catch by location.

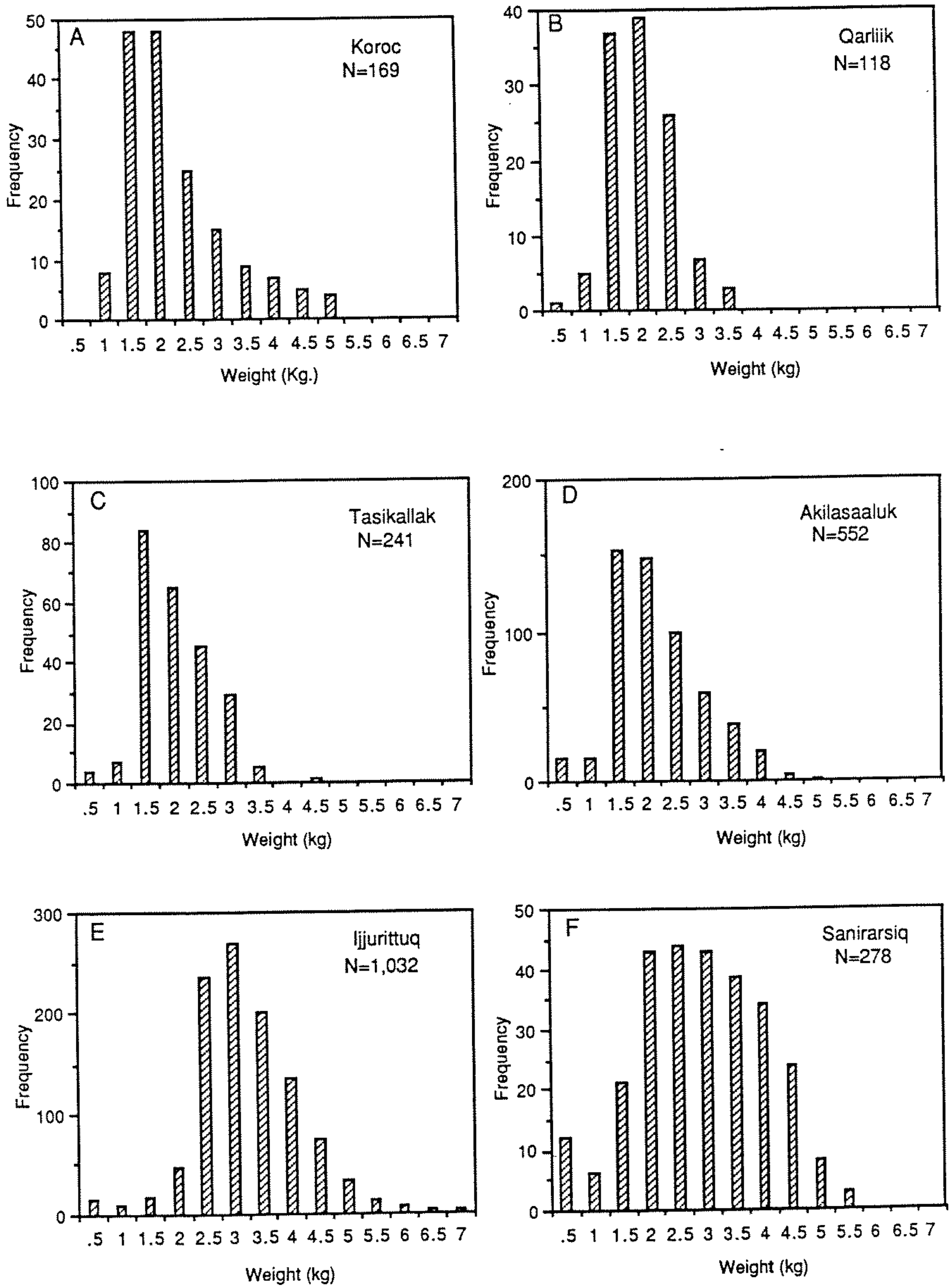

Figure 4: Weight-frequency distribution of the arctic char catch by location

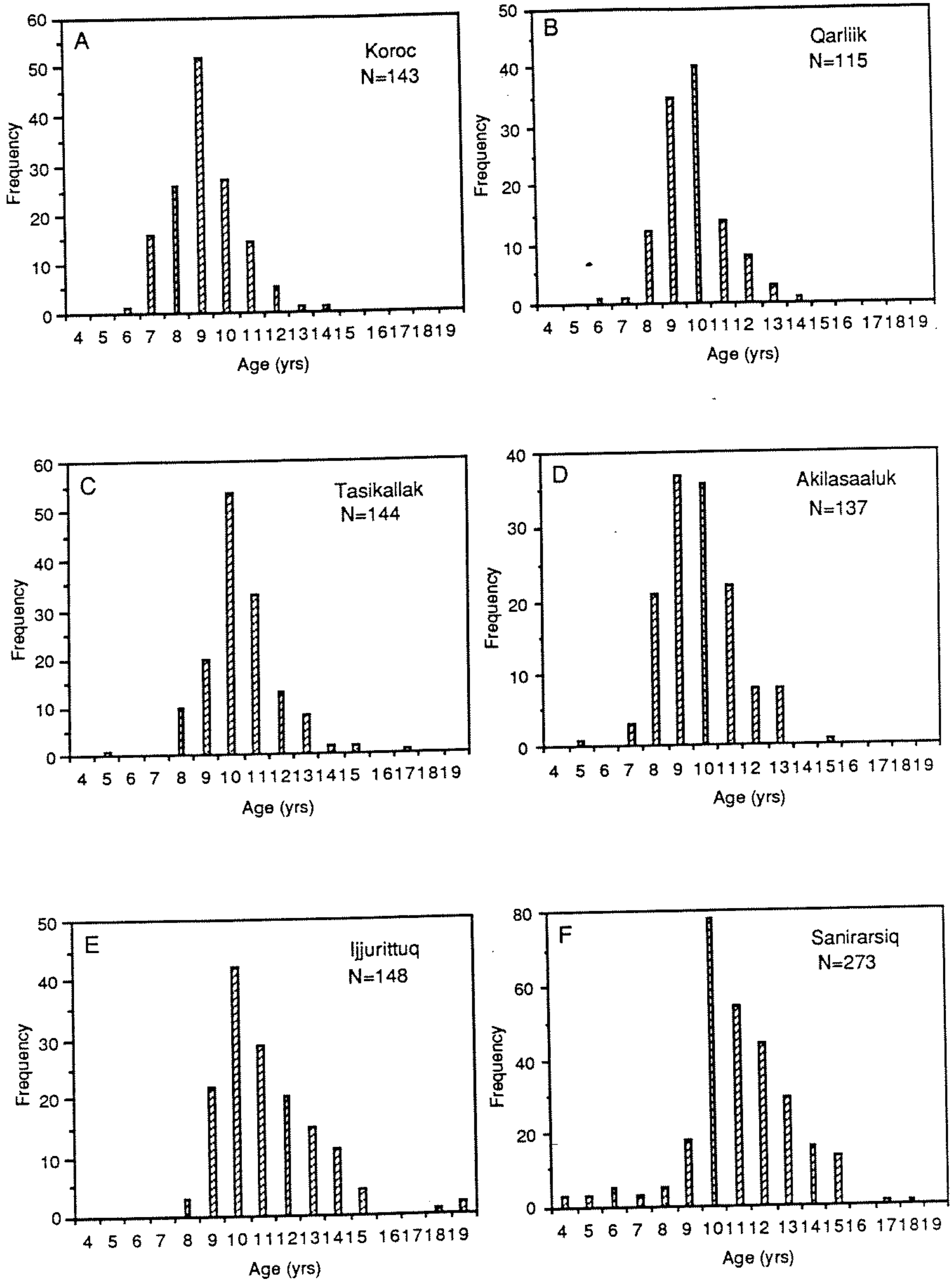

Figure 5: Age-frequency distribution of the arctic char catch by location

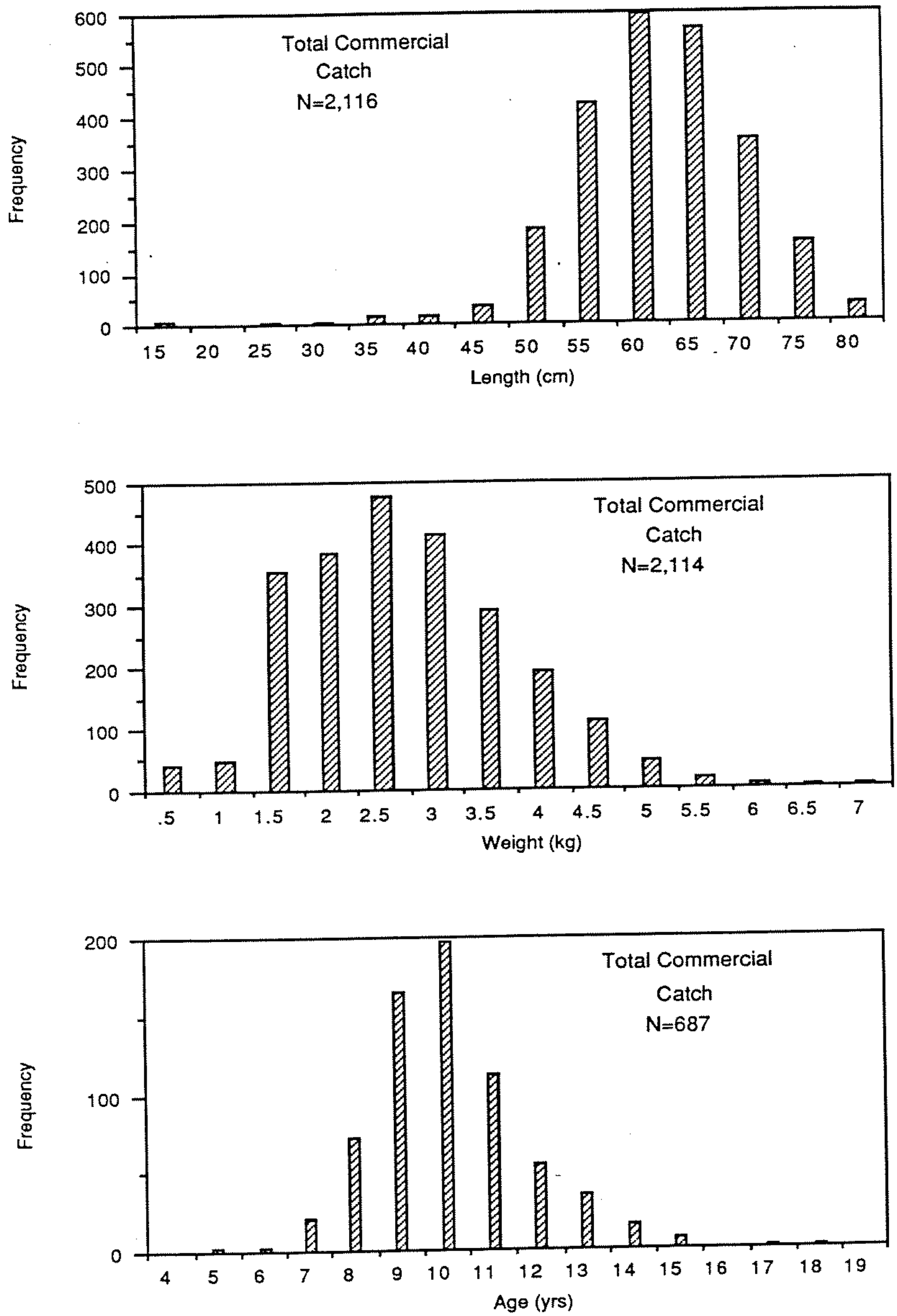

Figure 6: Length, weight, and age-frequency distributions of the total commercial catch

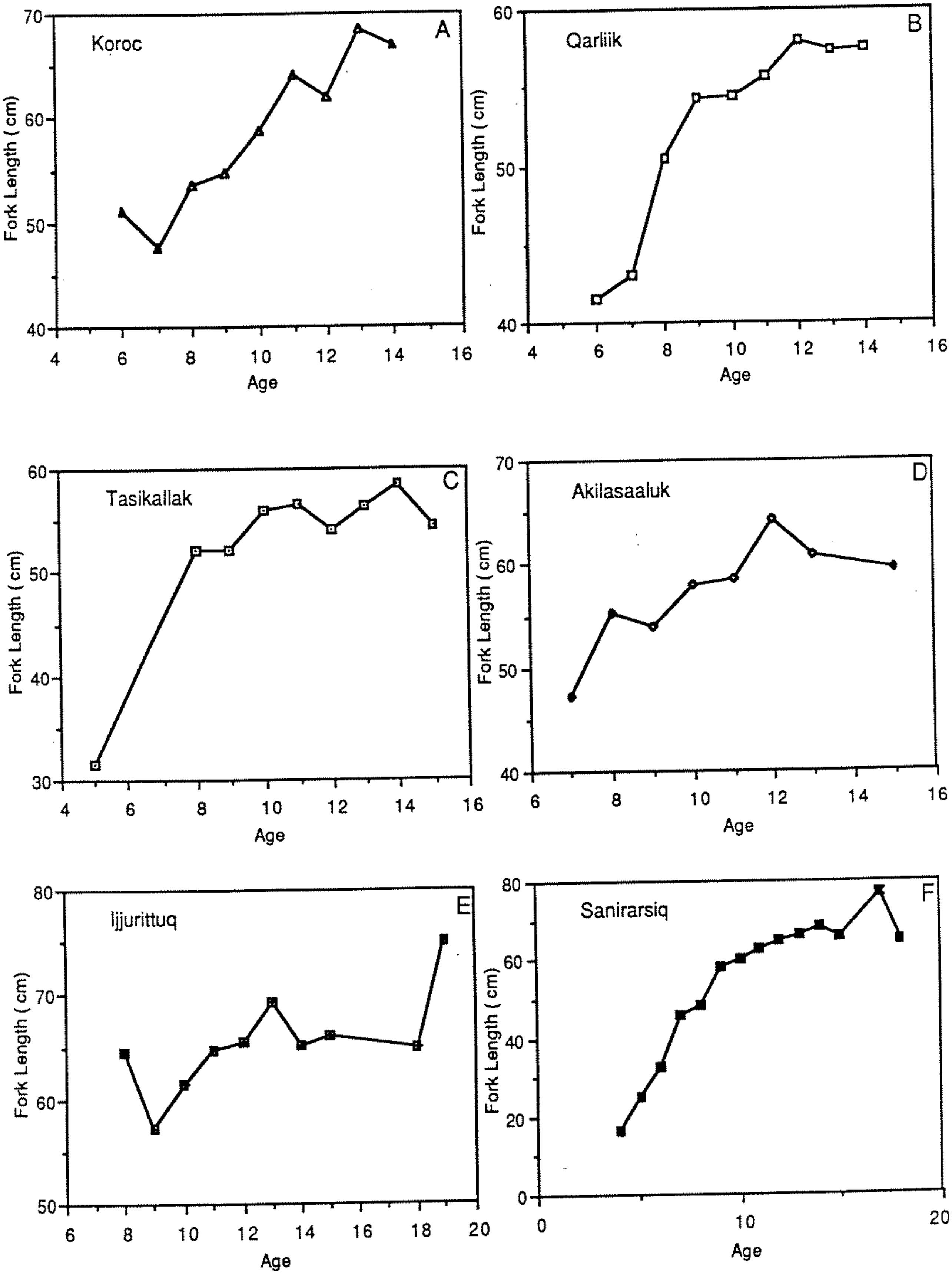

Figure 7: Growth curves (length vs age) of arctic char samples from all locations.

Table 1: Salmonid fish species harvested by gillnet from river and lake systems in the Kangiqsualujjuaq area. x=known occurrence of species.

System	Char	Salmon	L. trout	B. trout	Whitefish
Koroc	x	x	x	x	
Qarliik	x				
George R.	x	x	x	x	x
Tasikallak	x				
Akilasaaluk	x			x	
Ijjurittuq	x			x	
Napaartuliq	x		x		
Sanirarsiq	x		x		

Source: Boivin (1987); this study

Table 2: Results of arctic char subsistence harvest study conducted in Kangiqsualujjuaq between November, 1987- April, 1988. Total catches are separated by fishing methods; estimated net catches calculated from questionnaire data.

Location	Reported Net Catch	Estimated Net Catch	Jigging	Kakivak	Total
Koroc	1749	721	94	0	2564
Qarliik	93	45	0	0	138
Tasikallak	589	69	7	8	673
Akilasaaluk	30	0	0	0	30
Ijjurituk	27	0	0	2	29
George River	532	107	4	0	643
Sanirarsiq	0	0	4	0	4
Tunulliq	20	0	0	0	20
TOTAL	3040	942	109	10	4101

Table 3: Results of subsistence harvest survey conducted in Kangiqsualujjuaq between November, 1987 and April, 1988. Catches of other fish species (by gillnet) in known arctic char systems.

	Species					
Location	Salmon	Whitefish	B. trout	L. trout	Sucker	Total
Koroc	9	-	1	42	-	52
George R.	3	251	9	53	1	317
Tunnuliq	-	4	-	8	-	12
Total	12	255	10	103	1	381

Table 4: Species composition of subsistence gillnet fishery in Kangiqsualujjuaq, November, 1987-April, 1988.

Species	N	%
Char	4101	91.5
Whitefish	255	5.7
L. trout	103	2.3
Salmon	12	0.3
B. trout	10	0.2
Sucker	1	<0.1
TOTAL	4 482	100.0

Table 5: Commercial fishing effort (expressed in terms of gillnet-days) for all fishing locations (average (m) total net length/day is included).

Location	Total net Length/day	# net-days	#Char	Total Weight(kg)	#Char/ net-day	Weight(kg)/ net-day
Koroc	202	21	164	340.3	7.8	16.2
Tasikallak	326	7	241	441.0	34.4	63.0
Qarliik	167	9	118	210.2	13.1	23.4
Akilasaaluk	186	43	553	1102.3	12.9	25.6
Ijjurituk	243	106	944	2881.9	8.9	27.2
TOTAL	225	186	2020	4975.7	10.9	26.8

Table 6: Commercial fishing effort (expressed in terms of net-sets/day) for all fishing locations (average (m) total net length/day is included).

Location	Total net Length/day	# net-sets	#Char	Total Weight(kg)	#Char/ net-set	Weight(kg)/ net-set
Koroc	202	29	164	340.3	5.7	11.7
Tasikallak	326	12	241	441.0	20.1	36.8
Qarliik	167	12	118	210.2	9.8	17.5
Akilasaaluk	186	52	553	1102.3	10.6	21.2
Ijjurituk	243	121	944	2881.9	7.8	23.8
TOTAL	225	186	2020	4975.7	8.9	22.0

Table7: Mean fork lengths (cm) and whole weights (g) (± SEM) of arctic char sampled at commercial fishing locations.

Location	Mesh	N	Length (cm)	SEM	N	Weight (g)	SEM
Koroc	12	170	55.57	0.53	169	2052.52	71.14
Qarliik	12	118	54.34	0.46	118	1766.53	51.05
Tasikallak	12	241	54.70	0.38	241	1825.95	39.14
Akilasaaluk	12	552	56.17	0.30	552	1961.51	33.67
Ijjurituk	14	1035	63.07	0.23	1034	3056.22	29.04
TOTAL		2116	59.23	0.17	2114	2477.89	22.19

Table 8: Summary statistics for arctic char and lake trout captured during the experimental fishery at Sanirarsiq.

Species	N	F.L.	SEM	Wt.	SEM	Age	SEM
Char	278	61.03	0.61	2684.93	67.13	11.04	2.12
(Range)		(12.5-77.0)		(8-5450)		(4-18)	
L. trout	26	39.89	4.49	1520.63	505.96	13.77	2.01
(Range)		(12.0-95.0)		(15-8400)		(5-48)	

Table 9: Mean fork lengths (cm) (± SEM; range) of arctic char (both sexes combined) sampled with experimental gang-mesh nets at Sanirarsiq. Percentage non-selectivity of each mesh size is included, as well as samples captured by jigging.

Mesh (cm)	N	Length (cm)	SEM	Range	% Non-Sel. Catch
2.5	14	53.57	6.56	12.5-76.0	71
3.8	28	62.52	0.95	53.5-71.0	93
5.1	55	60.32	1.54	21.5-77.0	83
6.4	50	60.45	1.39	31.0-74.5	82
7.6	48	60.23	1.27	35.0-76.5	69
11.4	57	61.47	0.78	52.0-75.0	33
15.2	21	66.88	1.30	54.0-75.5	24
(Jig)	5	65.50	3.15	55.0-72.0	--
TOTAL	278	61.03	0.61	12.5-77.0	65

Table 10: Mean fork lengths (cm) (± SEM; range) of lake trout (both sexes combined) sampled with experimental gang-mesh nets at Sanirarsiq. Percentage non-selectivity of each mesh size is included.

Mesh (cm)	N	Length (cm)	SEM	Range	% Non Sel. Catch
2.5	2	30.75	18.75	12.0-49.5	50
3.8	9	31.11	7.23	18.0-84.0	22
5.1	5	36.10	9.27	22.5-71.0	40
6.4	4	36.00	2.80	31.0-44.0	0
7.6	2	41.50	0.50	41.0-42.0	0
11.4	4	75.00	12.16	42.0-95.0	100
15.2	0	-	-	-	-
	26	39.89	4.49	12.0-95.0	35

Table 11: Mean age (years) (± SEM; range) of arctic char sampled at commercial fishing locations.

Location	Mesh	N	Age (yrs)	SEM	Range
Koroc	12	143	9.13	0.11	6-14
Qarliik	12	115	9.80	0.12	6-14
Tasikallak	12	144	10.44	0.13	5-17
Akilasaaluk	12	137	9.81	0.13	5-15
Ijjurituk	14	148	11.13	0.15	8-19
TOTAL		687	10.08	0.07	6-19

Table12: Sex ratio, coloration and maturity of arctic char sampled at commercial fishing locations.

Location	Sex (♂:♀)	% ♀	Colour (silver:red)	% red	Maturity (ns:spent)	% spent
Koroc	88:80	47.6	129:41	24.1	123:27	18.0
Qarliik	80:38	32.2	103:15	12.7	------	-
Tasikallak	176:62	26.1	177:62	25.9	------	-
Akilasaaluk	255:295	53.6	458:93	16.9	------	-
Ijjurituk	686:343	33.3	829:189	19.7	544:160	22.7
TOTAL	1285:818	38.9	1696:400	19.1	667:187	21.9

Table 13: Length at age data for Koroc arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
6	1	51.00	-	-
7	16	47.56	0.60	44.50-52.00
8	25	53.52	0.83	46.00-66.00
9	49	54.68	0.63	47.00-66.50
10	22	58.66	1.26	50.50-68.00
11	2	64.08	1.40	56.00-71.00
12	3	62.00	3.51	55.00-66.00
13	1	68.50	-	-
14	1	67.00	-	-

Table 14: Length at age data for Qarliik arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
6	1	41.50	-	-
7	1	43.00	-	-
8	11	50.50	1.21	47.00-58.50
9	34	54.21	0.81	44.00-65.00
10	39	54.44	0.76	43.00-62.00
11	13	55.69	1.07	49.50-60.00
12	8	57.94	1.20	54.00-63.00
13	3	57.33	1.45	55.00-60.00
14	1	57.50	-	-

Table 15: Length at age data for Tasikallak arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
5	1	31.50	-	-
6	0	-	-	-
7	0	-	-	-
8	10	52.20	1.30	48.00-58.00
9	20	52.20	0.99	47.00-62.00
10	51	55.92	0.61	49.00-66.00
11	33	56.56	0.92	48.50-69.00
12	12	54.13	0.91	46.50-60.00
13	5	56.40	1.16	53.50-60.00
14	2	58.50	5.00	53.50-63.50
15	2	54.50	3.50	51.00-58.00
16	0	-	-	-
17	0	-	-	-

Table 16: Length at age data for Akilasaaaluk arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
5	0	-	-	-
6	0	-	-	-
7	3	47.33	3.94	40.00-53.50
8	19	55.31	1.53	47.00-71.00
9	36	53.89	0.73	47.00-62.50
10	36	57.93	1.12	47.00-73.50
11	20	58.58	1.35	49.00-69.50
12	7	64.29	2.95	48.50-72.00
13	8	60.81	2.68	45.00-72.00
14	0	-	-	-
15	1	59.50	-	-

Table 17: Length at age data for Ijjurittuq arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
8	2	64.50	5.50	59.00-70.00
9	22	57.18	0.95	45.00-67.00
10	41	61.43	0.75	50.00-70.50
11	29	64.69	1.17	46.00-75.00
12	20	65.40	1.32	55.00-74.00
13	15	69.27	1.53	56.50-76.50
14	11	65.14	2.15	54.00-78.00
15	4	66.00	3.40	60.50-75.00
16	0	-	-	-
17	0	-	-	-
18	1	65.00	-	-
19	1	75.00	-	-

Table18: Length at age data for Sanirarsik arctic char (both sexes combined). F.L.=Fork length

Age	N	Mean F.L. (cm)	SEM	Range
4	3	16.33	2.68	12.50-21.50
5	3	25.17	6.09	13.00-31.50
6	5	32.80	2.24	28.50-40.50
7	3	45.67	5.18	40.00-56.00
8	4	48.63	6.34	32.00-59.00
9	18	58.31	1.56	44.00-71.00
10	74	60.26	0.69	51.00-73.00
11	52	62.64	0.86	52.00-73.50
12	43	64.65	1.02	40.50-74.50
13	27	66.04	1.19	51.00-75.50
14	16	68.03	1.49	56.50-76.50
15	13	65.62	1.27	60.00-75.00
16	0	-	-	-
17	1	77.00	-	-
18	1	64.50	-	-

Table 19: Length-weight regressions for arctic char samples from commercial fishing locations and experimental fishery at Sanirarsiq.
Equation: Log Weight = Log (Intercept) + (Slope) Log Length

System		N	Intercept	Slope	r^2	p
Koroc	(all)	169	-2.325	3.214	0.884	<0.0001
	(silver)	128	-2.590	3.379	0.932	<0.0001
	(red)	41	-1.528	2.723	0.892	<0.0001
Tasikallaq	(all)	241	-2.183	3.122	0.907	<0.0001
	(silver)	177	-2.414	3.261	0.920	<0.0001
	(red)	62	-1.994	2.999	0.913	<0.0001
Qarliik	(all)	118	-2.079	3.059	0.619	<0.0001
	(silver)	103	-2.324	3.204	0.629	<0.0001
	(red)	15	-0.939	2.383	0.735	<0.0001
Akilasaaluk	(all)	552	-2.218	3.133	0.743	<0.0001
	(silver)	458	-2.207	3.134	0.843	<0.0001
	(red)	92	-2.758	3.405	0.488	<0.0001
Ijjurittuk	(all)	1063	-1.512	2.766	0.826	<0.0001
	(silver)	849	-1.259	2.630	0.712	<0.0001
	(red)	196	-1.484	2.731	0.854	<0.0001
Sanirarsiq	(all)	277	-2.633	3.369	6.862	<0.0001
	(silver)	223	-2.835	3.488	0.827	<0.0001
	(red)	51	-2.264	3.142	0.916	<0.0001

Table 20: Instantaneous total mortality (Z), annual mortality (A), annual survival (S), instantaneous fishing mortality (F), and exploitation rate (u_1 and u_2) for commercially-fished locations and the experimental fishery at Sanirarsiq during 1987-88.

Location	Z	A	S	F	u_1	u_2
Koroc	0.86	0.58	0.42	0.66	0.48	0.44
Tasikallak	0.79	0.55	0.45	0.59	0.45	0.41
Qarliik	0.79	0.55	0.45	0.59	0.45	0.41
Akilasaaluk	0.62	0.46	0.54	0.42	0.34	0.31
Ijjurituk	0.50	0.29	0.61	0.30	0.26	0.23
Sanirarsiq	0.40	0.33	0.67	0.20	0.18	0.16

Note: Calculations from Ricker (1975)

$M=0.20$

$u_1=1-e^{-l}$ (Assumes that natural mortality does not occur concurrently with fishing mortality)

$u_2=FA/Z$ (Assumes that natural and fishing mortality occur concurrently)